Higher-order interlayer exchange coupling in Nb-Fe and V-Fe multilayers

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Short-ranged interlayer exchange coupling play an important role in the properties and potential application of magnetic materials. However, the origin and nature of this interaction are not sufficiently clear [1]. In this contribution, we report results on the interlayer exchange coupling studies in (110) oriented Nb-Fe and V-Fe multilayers (MLs).The samples were prepared at room temperature (RT) on Si(100) wafers with an oxidised surface using UHV magnetron sputtering. A capping layer of 5 nm Pd was used to avoid oxidation of the top Fe sublayers and catalyse hydrogen absorption and desorption in the Nb and V sublayers. The chemical composition of all the layers was studied *in-situ* using X-ray photoelectron spectroscopy (XPS). The growth and interface mixing of the Nb-Fe and V-Fe bilayers were characterised *in-situ* by successive measurements of the XPS Fe-2p, Nb-3d and V-2p peaks for the samples with different sublayer thicknesses. Magnetic characterisation of the Nb-Fe and V-Fe MLs was performed in the temperature range 5-350K by successive hysteresis measurements using a Vibrating Sample Magnetometer in a magnetic field up to 9T. Moreover, RT hydrogen absorption in the Nb-Fe and V-Fe MLs was studied at a pressure of about 1000 mbar using four-point resistivity measurements. Results on XPS studies showed a limited interface mixing for the Nb-Fe and V-Fe bilayers deposited at RT. Furthermore, from the exponential variation of the XPS Fe-2p, Nb-3d and V-2p integral intensities with increasing layer thickness we conclude that the Fe, Nb and V layers grow homogeneously in the planar mode. The hysteresis loops revealed antiparallel alignment of the magnetic moments of the Fe sublayers and were fitted using bilinear (J1), biquadratic (J2) and cubic (J3) exchange constants. The interlayer antiferromagnetic coupling in the V-Fe MLs was also confirmed by magnetoresistance measurements. Results show that the biquadratic and cubic interlayer exchange coupling play an important role in magnetisation reversal of the Nb-Fe and V-Fe MLs. The higher-order interactions (J2 and J3) are especially important for Nb and V spacer thicknesses greater than 7 monolayers. Furthermore, the hydrogen absorption in the Nb and V spacer at RT below 1 bar can only suppress cubic interaction. The above effect is reversible and after hydrogen desorption the cubic interaction appears again. In conclusion, the cubic interlayer exchange coupling is sensitive to hydrogen absorption under mild conditions.

References:

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